Role of Transit Connectivity in a Multimodal Transportation Network

Sabyasachee Mishra; University of Memphis
Anupam Anand; University of Maryland, College Park
Timothy F. Welch; Georgia Institute of Technology
Paul M. Torrens; University of Maryland, College Park

Introduction
- Network connectivity can be used as a measure to study the performance of the transit system which will assist decision makers in prioritizing transit investment and deciding which stops/lines need immediate attention in regard to operation/maintenance.
- In this context, connectivity is one of the index measures that can be used to quantify and evaluate transit performance.
- A link in a road network is a physical segment that connects one node to another, a link of a multi-modal transit network is part of a transit line that serves a sequence of transit stops (nodes).
- Since a stop can be served by different transit lines, multiple transit links may exist between nodes in a multi-modal transit network.
- Headway, frequency, speed, and capacity are critical terms that define the characteristics of a route for a transit link. Similarly, transit nodes are composed of a different set of characteristics than highway nodes.

Motivation
Measures of transit connectivity can be used for a number of purposes.
- First, in a public or quasi-public agency, connectivity can be used as a measure in public spending to quantify transit stop and route performance and to evaluate the overall system performance.
- Second, in a rural or suburban area where exact information on transit ridership, boardings, and alightings are not available, to measure system coverage and accessibility.
- Third, to serve as a performance measure in a large-scale urban multi-modal transit network containing multiple modes.
- Fourth, to provide an assessment of effectiveness of a transit system with quantifiable measures that can be used to prioritize the nodes/links in a transit system, for reliability measure or emergency evacuation.

This work proposes a unique graph theoretic approach to measuring transit connectivity, particularly for applications where the use of transit assignment models or ridership tracking tools is not available.

Formulation
Node and Line Connecting Power

\[ P_{i,n}^L = P_{i,n}^O + P_{i,n}^I \]  

\[ P_{i,n}^O = a(C_i \times \beta_i \times V_i \times D_{i,n}^O) \]  

\[ P_{i,n}^I = a(C_i \times \beta_i \times V_i \times D_{i,n}^I) \]  

\[ P_{i,n} = a(C_i \times \frac{6}{5} \times v_i \times H_i \times 3 \times \delta A_{i,n}) \]  

\[ \phi_{T,n} = a(C_i \times \frac{6}{5} \times v_i \times H_i \times 3 \times \delta A_{i,n} \times \phi T_{i,n}) \]  

\[ T_{i,n} = \sum \frac{P_{i,n}^L}{P_{i,n}} \]  

\[ \theta_i = (|S_i| - 1) \times \sum P_{i,n}^L \]  

Case Study
Transit System

Baltimore, MD  Washington DC

Results
Node Connectivity
Rail Line Connectivity

Bus Connectivity
Line Connectivity

Connectivity, DC
Connectivity, Baltimore

GUI Interface

Conclusion
The proposed model has several dimensions of significant impact and contribution to practice:
- Incorporates graph theoretic approach to determine the performance of the multimodal transit network;
- Quantifies measures of connectivity at node, line, transfer center, and regional level;
- Applies methodology to demonstrate the proposed approach in a real world case study using GIS tools for seamless adaptation by users and decision makers.